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South Carolina Agricultural Experiment Station

OF

Clemson Agricultural College

Cotton Anthracnose

BY

H. W. BARRE

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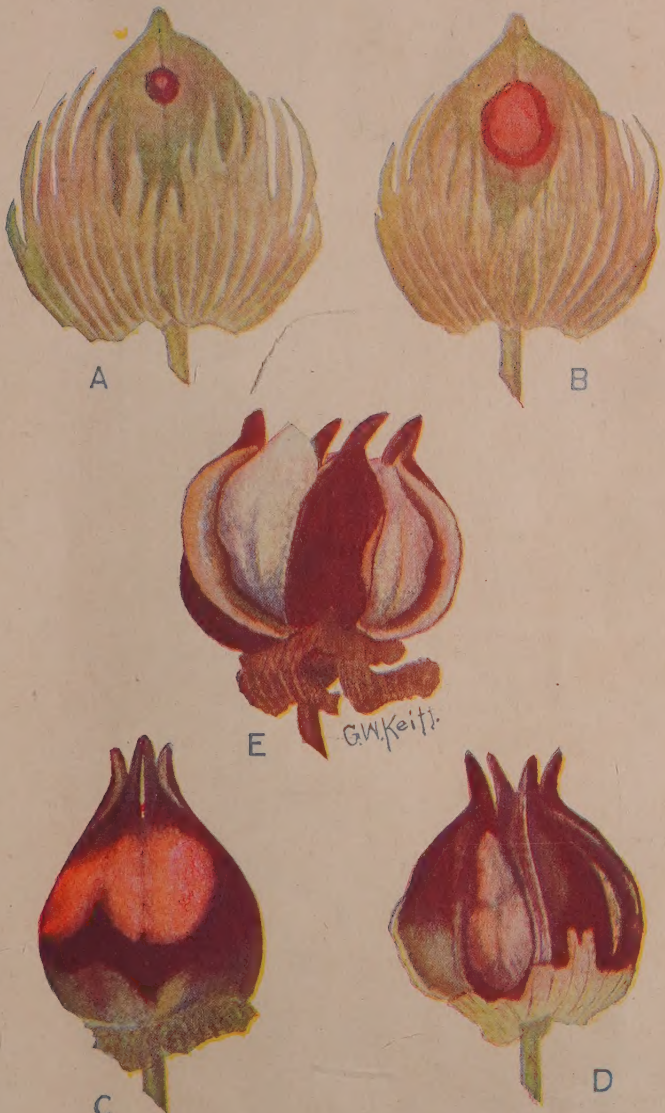


COTTON ANTHRACNOSE

Plate 1.

GILLA & MORROW, ANDERSON, S. C.

COTTON ANTHRACNOSE.

Introduction.

The careful study of cotton anthracnose was first made by Miss E. A. Southworth, of the United States Department of Agriculture, in 1890. About the same time Dr. G. F. Atkinson found the disease causing trouble in the fields of the Alabama Experiment Station and made a careful study as to its nature and cause. At this time anthracnose was supposed to be a new disease and little was known concerning it. Shortly after this, however, the disease became generally known through the South and is now recognized everywhere as a wide-spread and destructive disease. Little progress was made in the study of the disease between 1892 when Dr. Atkinson left Alabama and 1908 when the work was taken up here. Since 1908 publications on the subject have been issued by a number of the Southern stations and colleges but none of these have given any experimental evidence relative to methods for controlling the disease.

We have had the disease under investigation for four years, and as the work has developed a number of points have been brought out which aid materially in keeping the disease in check. These have been included in articles on the subject published in the Twenty-second, Twenty-third, and Twenty-fourth Annual Reports of the South Carolina Experiment Station. The articles are more or less technical in nature, however, and do not emphasize anything but the new facts brought out in the investigation. It seems that a publication is needed which will bring together our present knowledge of anthracnose and present it in such form that the laymen can readily understand the cause and nature of the disease together with methods of controlling same. The object of this publication is to fill this need and thus help the people of the State to know and understand this wide-spread and destructive disease.

Distribution and Prevalence of Anthracnose.

Anthracnose has been reported from every county in the State and it seems to be becoming more widespread in each county every year. In 1907 the disease was especially destructive here at Clemson and was reported as causing loss in other sections. Every year since that date it seems to have become more wide-spread. In 1910 the State agent of the farmers' co-operative demonstration work estimated that the loss in South Carolina amounted to as much as four million dollars. We have no means of making an accurate survey of the actual loss in the entire State, but careful estimates made on a number of individual farms during the past season show that on these farms the disease destroyed all the way from 10 per cent. to 60 per cent. of the crop. On one farm visited in Chester County anthracnose destroyed 25 per cent. of the crop on a 25 acre field. On one farm of 60 acres and another of 70 acres in the vicinity of Chesterfield the disease caused a loss of from 40 to 60 per cent. of the bolls. Near Cheraw about 10 per cent. of the bolls were destroyed on a farm of over 800 acres. On one farm between Timmonsville and Lamar six acres of cotton were so badly diseased that 50 per cent. of the bolls failed to open. On twenty different farms visited during the season careful estimates were made as to the loss caused by the disease. On these twenty farms including about 1800 acres in cotton such an estimate showed that anthracnose caused more than ten thousand dollars' loss. It seems safe to say from these estimates and from observavations made elsewhere over the State during the past three years that this disease causes more than a million dollars' loss every year in South Carolina.

The Disease.

The name anthracnose comes from two Greek words which mean carbuncle disease. The resemblance to the carbuncle is not as marked, however, in cotton anthracnose as it is in some of the other anthracnoses. The name seems to have been applied to the cotton rot because it is caused by an organism very similar to the ones which cause anthracnose of

other plants. Cotton anthracnose occurs on the bolls, leaves and stems of the plant and on the young seedlings. On each of these parts it causes a very characteristic disease.

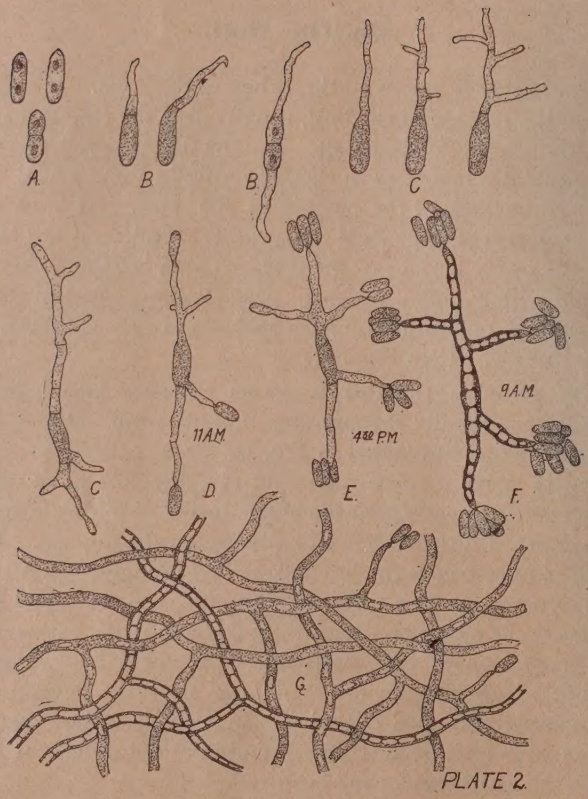
On The Boll.

Anthracnose seems to thrive best in the bolls. It appears first on the outside of the boll, usually near the tip, as a small dark to purplish colored spot. As the disease progresses the spot gradually increases in size, covering in some cases one-fourth to one-half of the surface of the boll. At any time after such a spot appears if the weather conditions are favorable, the whole surface of the diseased area is liable to become covered with a moist pinkish, pasty-looking mass of spores. This pinkish coloration on such surfaces is very characteristic of the disease. (See Plate 1.)

As soon as the disease gains entrance into a boll it spreads very rapidly through the lint and seed. When bolls such as the one illustrated in Fig. B, Plate 1 are cut open, the entire inside is usually found to be discolored and rotten. In fact we frequently find the entire inside of bolls destroyed when there is little evidence of disease on the outside. Bolls which mature before the lint and seed are completely destroyed partly open. In such cases the lint and seed are found to be compact and rotten and frequently covered with characteristic pink masses of spores. Bolls which are not so badly diseased or bolls which become diseased later in their development may mature and open out wide. In such cases, however, the lint is found to be discolored and does not appear as fluffy and white as it does in the healthy bolls.

On The Seedlings.

Anthracnose frequently attacks the young seedlings in the field when they are but a few days old. At this stage the disease attacks the cotyledons or seed leaves and the stem. On the cotyledons it forms irregular diseased areas around the edges. When the weather is cool and moist and unfavorable for the development of the young plants at this stage the diseased areas on the cotyledons encroach upon the healthy



A and B. Germinating spores.
C. Later stages of the same.
D. A young plant just beginning to form spores.
E. The same 5½ hours later.
F. Same 16½ hours later than E.
G. A few fungus filaments.
(All greatly enlarged.)

tissue until the seed leaves are entirely destroyed. If the conditions are favorable for the development of the young plants the disease seems to make little progress, and the plants overcome the trouble. In such cases the diseased cotyledons will hang on until two or three pairs of true leaves have formed. The disease remains alive on these seed leaves and other leaves that drop to the ground and on the leaf scars from which such leaves fall. From here it attacks the bolls when they appear.

The most destructive form of the disease on the seedlings occurs on the stems. Where this phase occurs the young seedlings are found to turn yellow and to look sickly. An examination of such plants reveals the fact that the stems are dark colored and diseased. In such cases the disease seems to do most of its damage at or about the surface of the soil. All of that part of the stem which is underground is usually found, however, to be diseased. During cool spells in the spring the stand is frequently entirely destroyed by this stage of this disease. This is especially true when diseased seed are planted.

Cause of The Disease, The Fungus.

Cotton anthracnose is caused by a fungus which is technically known as Glomorella gossypii. This fungus which resembles in some respects the ordinary moulds which occur on rotten fruits, musty pastry, etc., is a colorless filamentous plant. It is made up of numerous minute threadlike filaments which are invisible to the unaided eye. Some of these filaments as they appear under the microscope are shown at Fig. G, Plate 2. These tiny colorless threads grow into the cells of the plant, destroy the tissue and cause disease. The fungus attacks the boll from the outside, the strands grow in through the tissues of the boll wall and cause diseased spots such as shown at Figs. A and B, Plate 1. The fungus filaments as they appear in the tissue of such diseased areas are shown in Plate 3. These filaments grow through the boll walls into the lint and seed beneath. The fungus as seen in the lint fibers is shown at C, D and E and in the seed coats at A, Plate 4.

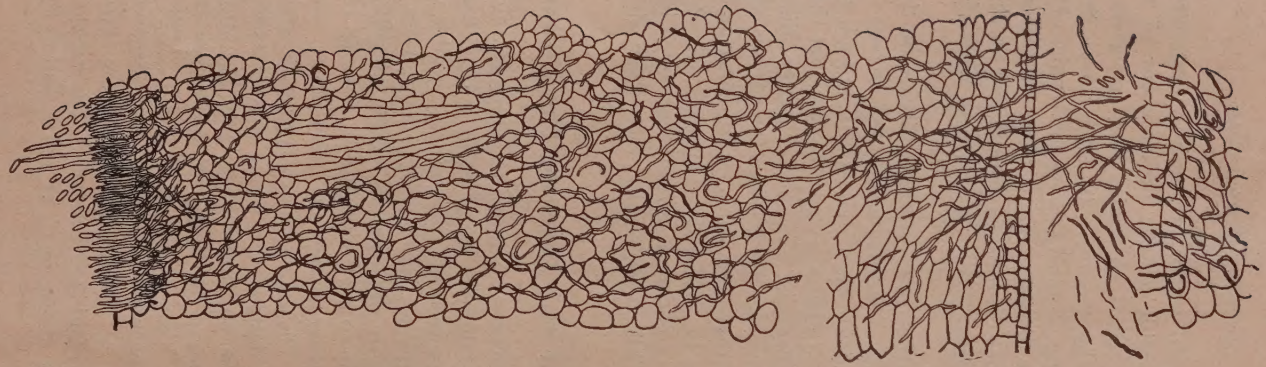


PLATE 3.

Section of young boll, showing the fungus penetrating the hull of the boll, and entering the young seed. Spores are being produced upon the outer portion of the boll hull upon the surface of the young seed coat.

The fungus reproduces itself and spreads from one place to another by means of spores. These spores serve the same purpose for the fungus that seed serve for higher plants. They are produced on the ends of branches of the fungus filaments as seen in Fig. E, Plate 2. One spore is formed at a time on each branch and this is pushed aside by another which grows out and forms in the same place. In this way in a very short time a group of spores is formed around the end of each spore-producing branch of the filament. The rapidity with which these spores are produced is shown in Figs. D, E and F, Plate 2, where a portion of the same filament was kept under the microscope for 24 hours and drawings made of it at intervals. During moist warm weather masses of spores are formed on the surfaces of the diseased areas of the bolls and on the decaying lint and seed. Where spores are formed in such abundance they appear as a pinkish colored pasty mass as is shown in Plate 1. The method of spore formation on the surface of diseased areas is shown in Plate 3.

These spores as stated above have the same function as seed, and it is through the agency of these that the disease spreads during the summer. The spore masses are formed on all diseased surfaces. These are first noticed in spring on the diseased stems and cotyledons of the seedlings. The spores here serve to spread the disease from one seedling to another.

When the seed leaves drop to the ground or the diseased seedlings topple over and die, the disease continues to thrive there and the spores remain alive for several months. The fungus also remains alive on the leaf scars of the diseased plants.

From these places the spores spread the disease to the young bolls as soon as they begin to develop. From one diseased boll such spores spread to others on the same or on neighboring stalks.

In order to determine what per cent. of the bolls on which such spores of the fungus happen to lodge become diseased, we made a large number of inoculations on cotton bolls in the field. These inoculations were made by mixing the spores in

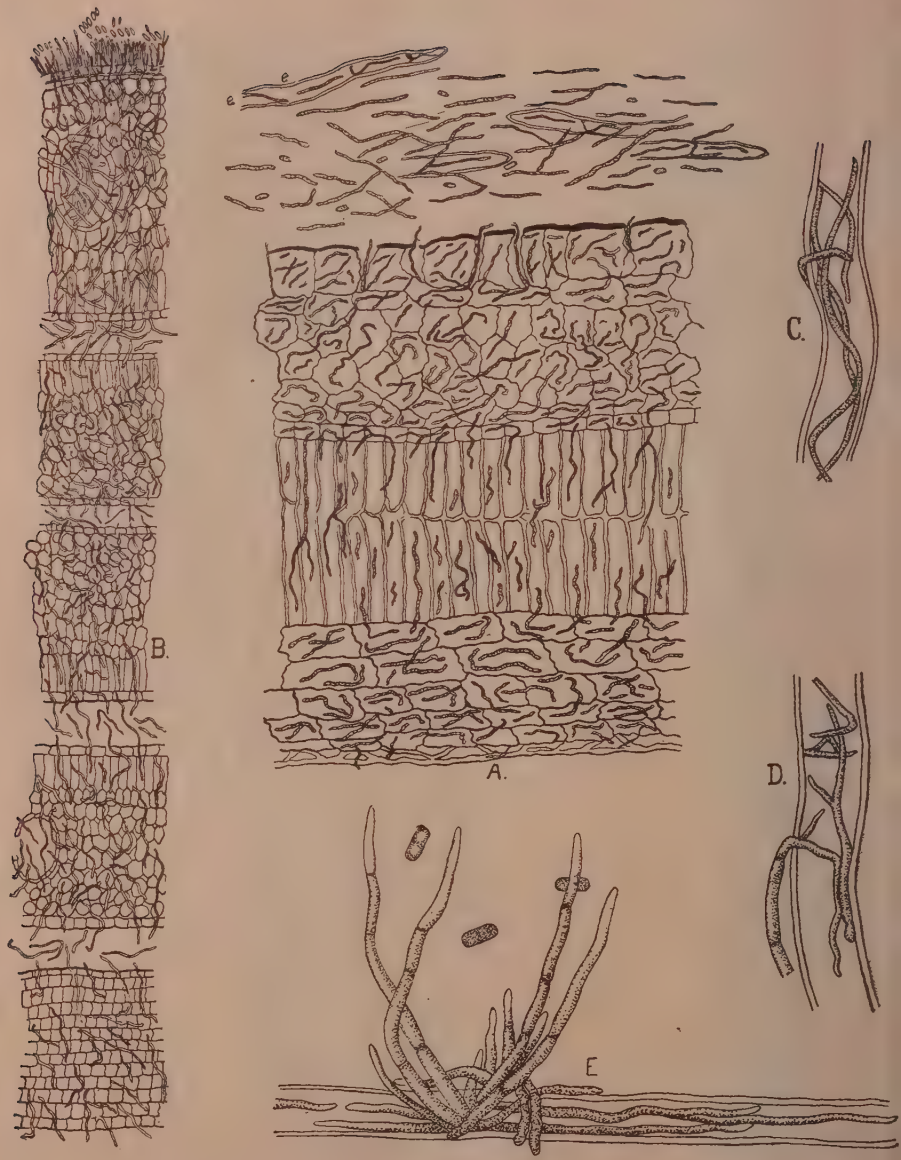


PLATE 4

A, Fungus in seed coats. B, Fungus and spores in tissue of seed. C, D, E, Fungus growing in lint fibers.

sterile water and spraying on to the bolls with a small atomizer. The spores were placed in this way on over a thousand bolls and the majority of them developed typical cases of the disease. This indicates that where spores of the anthracnose fungus lodge on a cotton boll and find conditions favorable they grow and cause the disease.

Water seems to be a more important agent in the spread of the disease than air. While fungus spores usually float around in the air much the same as dust particles, this does not seem to apply to the anthracnose spores. The pasty mass in which these spores are formed acts as a cement and when it dries sticks together and hardens. When a drop of water touches one of these spore masses the paste is softened and the spores at once become suspended in the water. During rain storms the drops spatter on these diseased areas and in this way spread the disease to other bolls and stalks.

The Fungus in The Seed.

When we come to study carefully the seed and the way the fungus works on the inside of the boll we can readily understand why it is that the seed are so important in the spread of the disease. When a boll is attacked by the fungus while it is quite young, the entire boll, including the seed and lint is destroyed. Such bolls cause no further trouble except to furnish a place for the fungus to pass the winter. Where the boll is attacked later in its development, however, the lint and seed may mature and the boll open. The condition of the lint and seed in such a boll will depend of course on the extent to which the boll is diseased. The lint may be compact and discolored or it may open out wide with little evidence of disease. The seed in such bolls frequently mature and when planted will germinate and grow. Diseased seed and lint are frequently found, in fact, in bolls which to the casual observer, do not appear to be diseased at all. A photograph of such a boll is reproduced in Plate 6. A section of a seed from this boll is shown in Plate 5. A careful study of this seed reveals the fact that a cotton seed is nothing more nor less than a little plant with its small stem already formed and with its seed leaves already developed and folded

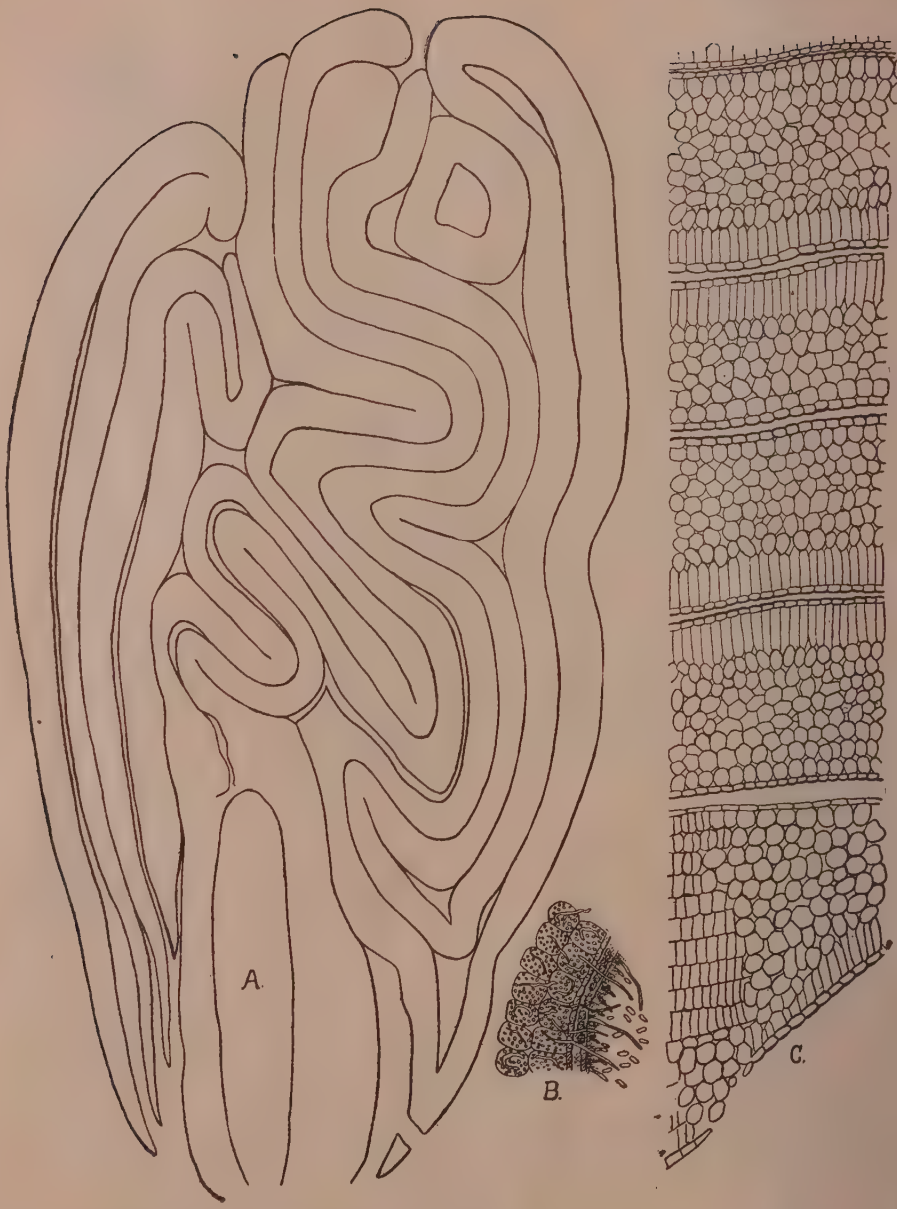


PLATE 5

A—Section through the center of a cotton seed with seed coats removed showing how the cotyledons are folded inside a mature seed. Magnified 20 diameters.
B—Portion of one of the cotyledons showing fungus filaments penetrating the tissue. Magnified 30 diameters.
C—Section of A, enlarged (X 136) showing structure of cotyledons.

up inside the seed coats. When such a seed is planted, the little stem lengthens out and pushes up above ground where the leaves unfold. Plate 7 shows small plants with the seed leaves only partly unfolded. Fig. B, Plate 5 shows the fungus growing into the outer layer of the seed leaf as it is folded up inside the seed coats. The fungus in such seed seems to remain dormant as long as the seed is inactive or in the resting stage. This is probably due to the lack of water. As soon as moisture and warmth are supplied, however, and the seed begins to grow the fungus takes on new life and makes a vigorous attack upon the tissue of the seedling plant. It is easy to see then how this fungus which is already present on the seed leaf in the seed causes disease when the seedling starts to grow and the leaves are unfolded above ground. Plate 7 shows such seedlings with the disease on the cotyledons.

The Kind of Bolls Which Produce Diseased Seed.

It seems from the investigation carried on here during the past three years that any boll which is diseased at all may contain diseased seed. The most common form of diseased boll which contains diseased seed is the boll with only one or two locks destroyed and the other locks mature and open, such boll as is seen in Plate 1, Fig. E. We find that practically all of the seed in the open locks from such bolls are diseased and when planted will produce diseased plants. Bolls are frequently found which are not badly diseased at any particular point but in which the lint is slightly discolored. Such bolls do not open out wide and when examined with microscope are found to contain diseased seed. Still another form of diseased boll is that already referred to and illustrated in Plate 6. This boll to the casual observer would appear perfectly healthy. Upon closer examination, however, the lint is found to have a slightly darkish tinge and the divisions of the boll have not curled back and opened out quite as wide as in a perfectly healty boll.

Vitality of The Fungus.

A careful study has been made of the vitality of the

fungus in order to determine how long it lives under different conditions in the field and in the seed.

In the Field.

During the past three winters the fungus has been studied in the field and in the laboratory. We find that the spores

PLATE 6

Slightly diseased boll.

and filaments of the fungus will remain alive in the field for about twelve months, but that no part of the fungus remains alive for a longer time than this. This indicates that where cotton is left off the land for one year the fungus will be starved out. This has proven true in practice.

During the past winter we made a study of the disease in the field with a view of finding under what conditions the

fungus lives longest there. A number of diseased bolls were buried at different depths in the soil and a number of stalks containing diseased bolls were piled out on the edge of the field. Bolls from both of these places were brought into the laboratory from time to time during the following spring and summer and the fungus in them studied under the microscope and in culture. The fungus did not live in the buried bolls longer than the middle of March. It remained alive in the bolls which were left on the stalks until the following September. This would indicate that any method of burying the bolls, such as fall plowing, would aid in destroying the disease. This proved true in practice last season.

In the Seed.

A large number of tests have been made with a view of determining how long the fungus will remain alive in the seed. This phase of the work has been prolonged because when the investigation was started we had no seed with a definite history that were more than one year old. We now have seed three and a half years old, however, that came from a field where 35 per cent. of the bolls were destroyed by the disease. Where the seed were so badly diseased, that their vitality was destroyed the fungus did not live for more than 12 to 15 months. Where the seed were only slightly diseased, however, the fungus remained alive at the end of the second year and in a few cases until the end of the third year. Since the end of the third year we found no fungus alive in the seed and have had no disease develop on the seedlings grown from them.

On the Outside of the Seed.

When the seed are diseased we always find filaments and spores of the fungus on the outside of the seed in the fuzz and short lint that covers the outer seed coat. It also frequently happens where healthy bolls are on the same stalk with diseased bolls or where diseased cotton and healthy cotton are ginned together on the same gin that healthy seed have spores of the anthracnose fungus clinging to this fuzz which

PLATE 7

Disease cotton seedlings showing the disease on the stems and in the cotyledons.

covers the outer seed coat. We have conducted a number of tests with a view of determining how long such spores remain alive. The results of these tests indicate that such spores will remain alive on the outside of the seed under the conditions in which seed are ordinarily kept for about nine months after the cotton is mature. This of course indicates that it is not safe to gin seed cotton along with cotton which is diseased and emphasizes the necessity of picking seed cotton from stalks which are free from disease.

Detection of the Disease in the Seed.

Since the seed is an important factor in the spread of the disease and since there is no way of telling from looking at it whether the seed is diseased or not, it seemed advisable to try to find some method of detecting the disease in the seed. We have been working on this during the past year and have succeeded in developing a method by which we can tell whether or not any given sample of seed is diseased. We found that when diseased seed were germinated the disease would show up on the resulting seedlings. By germinating the seed then under sterile conditions so as to be sure that they did not contract the disease from each other or from outside, we found that we could tell from the number of diseased seedlings which developed from 100 seed in a given sample about how badly the seed were diseased. We take out 100 seed from a sample and place each seed in a test tube with a few small pieces of blotting paper and a little water. Then place the tubes in a germinator and wait for the seed to grow. In about a week the seedlings will have developed to such an extent that the disease if present will show up on the young stems and seed leaves.

We can also tell with a fair degree of accuracy how badly diseased a given sample of seed is by what we call the "centrifuge test." In this test we wash a given number of seed with distilled water long enough to wash off any spores which may be on the outside of the seed and then draw off the water and place some of it in an ordinary physician's centrifuge. The centrifuge causes the fungus spores to congregate at the bottom of the tube from where they can

easily be removed and examined under a microscope. For full discussion of the method see 24th Annual Report of this Experiment Station pp. 43.

Weather Conditions.

Practically all fungus diseases are affected by weather conditions. This is especially true of anthracnose. Cool spells during April and May are very unfavorable for the growth of the young cotton plants. The fungus takes advantage of this and attacks the plants during such spells while they are in a weakened condition. If the weather is sufficiently moist at such times the fungus spreads rapidly and the disease destroys quantities of the seedling plants. On account of the ravages of the disease at this season of the year it is frequently impossible to get a good stand of cotton.

Moist warm weather in summer also encourages the development and spread of the disease. This is especially true during August and September, the time when the bolls are developing. Rain storms at this season serve to spread the disease and the warm moist weather favors the rapid development of the fungus. Dry weather on the other hand serves to keep the disease more or less in check.

Varietal Resistance.

There seems to be a great deal of difference in the susceptibility of the different varieties of cotton to anthracnose. Such varieties as Cook, Brown, Blue Ribbon, Columbia, Triumph, etc. seem to be much more subject to the disease than such varieties as Toole, Peterkin, King, Cleveland and others. While observations have been made by a number of workers on this point, no carefully planned experiments have been made which show just what the difference is.

We made inoculations on thirty different varieties of cotton here on the Experiment Station farm two years ago with a view of getting some data on this point, but a dry spell which came just at the time that the inoculations were made caused so many of the bolls to shed that no direct comparison could be made. We found, however, that some

of the inoculated bolls in every variety contracted the disease. This shows very clearly that none of the varieties were absolutely immune to anthracnose. A large number of the varieties have not been grown on the farm since so we have not had opportunity to repeat this test. Observations made at many points in the State, however, bear out the conclusion that all varieties are more or less subject to the disease. Last season I visited one field where anthracnose had destroyed 20 per cent. of the bolls in a 50 acre field of Cleveland Big Boll. This was the first time I had seen this variety badly diseased. One case was reported last season where the disease destroyed 10 per cent. of a field of Toole. Similar reports have been made with reference to King and Peterkin and several other supposedly resistant varieties. This indicates that even the varieties which are considered most resistant sometime suffer considerable loss from attacks of anthracnose. I am convinced therefore that it is more important to keep the disease off your farm than it is to try to get a variety which is resistant to it.

Methods of Controlling Anthracnose.

During the past three years we have conducted experiments relative to methods of controlling anthracnose and have been able to demonstrate that the disease can be controlled. The methods which have proven successful in controlling the disease include seed selection, crop rotation, and fall plowing.

Seed Selection.

As soon as we discovered two years ago that the anthracnose fungus grew into the seed and remained alive there until the seed were planted, we undertook to control the disease by seed selection. In the fall of 1909 we went into a field where the disease had destroyed 20 per cent. of the bolls and picked cotton from healthy stalks and bolls in order to get seed which were free from disease. These seed were planted the next spring on land which had not been in cotton for one year. The cotton which developed from such seed showed no sign of disease. Cotton grown from seed from the same

field which were not selected and were planted on land which had not been in cotton the previous year showed an abundance of anthracnose. This same experiment was repeated the past season with the same results. By simply going in the field and picking cotton for seed from healthy stalks and bolls we have been able to get rid of the disease in our three worst diseased varieties of cotton, viz., Cook, Columbia and Blue Ribbon. This method was practiced under our direction by a number of farmers over the State during the past season, and in every case where the selections were properly made they got rid of the disease. Seed selection then is a simple and effective method of getting rid of the disease.

A careful study of the history of a number of cases of anthracnose over the State showed that the disease was brought on to practically all of these farms through the seed and usually through seed of some supposedly highly improved variety bought from a seedsman at a fancy price. The disease, it seems, has been brought into communities and carried from farm to farm in this way until it is now present in almost every community in every county in the State. It must be kept in mind, therefore, that while we are making an effort to get rid of anthracnose by careful seed selection we must at the same time guard against reinfecting the farms through diseased seed brought from outside. It is now unlawful to bring seed into the State or to transport them in the State if they are for seeding purposes if they contain anthracnose.

Crop Rotation.

A careful study of the life history of the fungus showed that the anthracnose fungus remains alive in the old diseased stalks and bolls in the field for about a year but not for a longer time than this. Knowing this, we conducted rotation experiments with a view of controlling the disease by leaving cotton off of the land for one year. Such experiments have been carried on now for three years in succession and every case where we left cotton off of the land for one year or longer and then planted back in seed which were known to be free from the disease we have had no further trouble with anthracnose. In one particular field anthracnose destroyed 35 per

cent. of the crop in 1908. This field was plowed and sown in oats that fall and after the oats came off in the spring it was plowed again and sown in peas. The following spring—April 1910—it was planted in the same variety of cotton but with seed which were known to be free from disease. No disease at all was present in this field that season. On the other hand in adjoining fields where rotation had not been practiced nor seed selected, the disease was as prevalent as in previous years.

Fall Plowing.

A study of the vitality of the fungus in bolls which had been buried in the soil as compared with the length of time the fungus would remain alive in bolls above ground, indicated that fall plowing would be a distinct advantage in controlling the disease. Accordingly a field on which the disease had destroyed 20 per cent of the bolls in 1910 was plowed in November of that year so as to turn under all of the stalks and bolls. A stalk chopper was first run over the stalks and then the land was plowed to a depth of about 10 inches with a disk plow. The land was then harrowed and sown in clover. The next spring, 1911, it was planted back in cotton—the same variety but with seed from a field where there was no disease. There was no disease at all in that field that summer. While this is the result of a one season's test, it indicates, when taken in connection with the study of the vitality of the fungus in buried bolls that fall plowing is an important factor in controlling anthracnose. This would seem to be especially true where land is planted continually in cotton. This experiment will be continued during the coming season.

Summary.

Cotton anthracnose is a wide spread and destructive disease in South Carolina.

The disease is caused by a fungus which grows as a parasite in the parts of the plant and destroys the tissues.

This fungus which causes the disease grows into the seed before they are mature and remains alive there until the seed are planted.

When such diseased seed are planted in less than three years from the time of maturity they produce diseased plants.

Diseased seed is the most important factor in the spread of the disease.

By careful selection, seed which are free from anthracnose can be secured from a field where the disease is present.

The fungus which causes anthracnose does not remain alive in the field for more than one year.

Crop rotation and seed selection will control cotton anthracnose.